Proportionally they suffer from the ravages of the birds equally; the percentage of losses is the same; they are on equal terms. No matter how long they continue the association, neither gains nor loses on the other; though through one being more numerous it loses more individuals, yet equally in proportion with the other. So that, if one is twice as numerous as the other at the time of assimilation, it must always—other conditions being equal—remain twice as numerous.

We now give the mathematical reduction :—

Designation of species	A	B
(1) Original number	a >	b
(2) No. lost without imitation ...	e =	e
(3) Remains without imitation ...	$(a - e)$	$(b - e)$
(4) No. lost with imitation ...	$\frac{a}{a+b}e$	$\frac{b}{a+b}e$
(5) Remains with imitation	$a\left(1 - \frac{e}{a+b}\right)$	$b\left(1 - \frac{e}{a+b}\right)$
(6) Excess of remains due to imitation, or *absolute advantage* (3)–(5)	$\frac{be}{a+b}$	$\frac{ae}{a+b}$
(8) Ratio of excess to remains without imitation (6) : (3), or *proportional advantage*	$\frac{e}{a+b}\cdot\frac{b}{a-e}$	$\frac{e}{a+b}\cdot\frac{a}{b-e}$
(9) Ratio of proportional advantage of B to proportional advantage of A	$\frac{a(a-e)}{b(b-e)}$ or $\frac{a^2}{b^2}\cdot\frac{1-\frac{e}{a}}{1-\frac{e}{b}}$.	

From (8) we see that, if $e < b < a$, there is a proportional advantage to both, the mimicry "is twice blessed," but the proportional advantage to B is greater. If e is zero, there is no advantage to either. If $e = b < a$, the prop. advantage to B is infinite, while that to A is still finite; this is as it ought to be, seeing that to B it is a case of "to be or not to be," of existence with mimicry or extinction without. And in this extreme case it must be evident to every one that the ratio of $a^2 : b^2$, both terms finite, cannot be the ratio of the infinite advantage of B to the finite advantage of A. The greater e the greater are both advantages.

From (9) we see that, if e is small compared to b and a, the ratio is nearly $a^2 : b^2$ (Müller's law), but the larger e is the further it deviates from that law, the ratio becoming rapidly greater than $a^2 : b^2$, and approaching infinity as e approaches b.

To conclude, we may point out that Müller's law, as given in his own words and quoted above, is incompletely enunciated, and but for the numerical examples, it might lead any one astray as to what the law is. It ought to have *the ratio of* interpolated between "and" and "the *proportional*"; then "*advantage*" and "*square*" ought both to be plural; "relative" ought to be respective; and, lastly, the fact that the ratio is inverse should be explicitly stated.

Finally we enunciate our law. Let there be two species of insects equally distasteful to young birds, and let it be supposed that the birds would destroy the same number of individuals of each before they were educated to avoid them. Then if these insects are thoroughly mixed and become undistinguishable to the birds, a *proportionate advantage* accrues to each over its former state of existence. These *proportionate advantages* are inversely in the duplicate ratio of their respective original numbers compounded with the ratio of the respective percentages that would have survived without the mimicry.

This last "ratio compounded" correct Müller's law, but we still think with Mr. Wallace that the law, even when corrected, has not much bearing on the question that the individual absolute advantages (6) above, together with the probable value of e and the ratio $a : b$ indicated by relative frequency of capture, solve the whole question. In our first paper above mentioned we established formulæ for calculating these last-named items, although in a different manner from and quite independent of Müller's law, which we had not then seen.

THOMAS BLAKISTON
THOMAS ALEXANDER

Tokio, Japan, November, 1883

Christian Conrad Sprengel

I BECAME acquainted with Christian Conrad Sprengel's work, "Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen" (Berlin, 1793) in 1850 at the University of Berlin through Prof. C. H. Schultz-Schultzenstein, who brought it forward in one of his lectures on botany, praising Sprengel's good observations and illustrations, but making his teleological views appear so irksome as to dispose his hearers rather to depreciate and reject the book than be attracted to it by respect. The value of Sprengel's treatise in its bearing on the theory of selection was first recognised by Charles Darwin, whose writings recalled the remarkable book to my mind, and induced me to buy it, which I did at a very cheap rate at an old book-shop.

K. MÖBIUS

Kiel, February 18

Circular Cloud Bows

I FANCY that the phenomenon described by Mr. Fleming in your issue of January 31 (p. 310) is not a very uncommon one. It has twice fallen to my lot, when in Switzerland, to be a witness of these spectral shadows.

On the first occasion I was with a party of three on the mountains to the north-east of Montreux, almost opposite the Cape de Moine. It was midwinter, and the day was very cloudy, even in the valleys, while the high ground on which we stood, and all the surrounding peaks, were completely swathed in mist. Suddenly, and under the impulse apparently of a blast of wind from below, the mists around us were almost entirely dissipated, and a few sickly gleams of sunshine filtered through the fog. At that moment we saw gigantic images of ourselves projected on to the wall of vapour enshrouding the Cape de Moine, immediately opposite the point where the sunbeams had permeated. The effect was very transitory, and, so far as I remember, there were no prismatic colours.

The circumstances under which I saw the second appearance were as follows :—

In August last I was standing, just before sunset, on the summit of the Niesen, in company with a friend. The day had been very hot, and we were just remarking on the extraordinary difference in temperature between our elevated position there and our situation a few hours before on the Lake of Thun, when we saw some scattered wisps of cloud rising out of the depths below. These increased rapidly, both in size and number, uniting as they rose, till the whole abyss presented the appearance of a seething cauldron, from which was escaping a dense cloud of steam. The prospect towards the east was quickly blotted out, while the sky in the opposite quarter remained as clear as before.

We then saw dim and fragmentary signs of prismatic colours in the curtain of cloud, and these became more defined and vivid as the thickness of the cloud increased. Finally there appeared a very distinct circle of rainbow hues, with our own figures looming, weird and awful, in its centre. Both images were visible to myself and my companion, though each could see the other's reflection more distinctly than his own.

Mr. Whymper, in his "Ascent of the Matterhorn," mentions an instance in which the prismatic colours assumed the shape of crosses. This effect, occurring as it did soon after the fatal accident which marked the conquest of the mountain, filled the minds of the guides with superstitious horror. From my own experience on the Niesen I can well imagine that, as Mr. Whymper suggests, this form could be accounted for by the supposition that there were several circles interlaced, and that only segments of them were visible from the point at which he and his companions stood.

Perhaps some of your readers may be able to explain the exact atmospheric conditions under which these appearances become possible.

E. H. L. FIRMSTONE

Bewdley, February 21

On the Absence of Earthworms from the Prairies of the Canadian North-West

IN NATURE of Jan. 3 (p. 213) Mr. Robert M. Christy writes on the absence of earthworms from the prairies of the North-West. I can confirm his statements, and extend them to cover the prairies of Kansas, the Indian Territory, Idaho, and Washington Territory. In all the above-mentioned territory of the United States the soil is more or less alkaline, and it seems to

me that to this cause the absence of earthworms may be attributed. Ants and burrowing beetles, or the larvæ of the latter, are, however, common, and no doubt do much service in the manufacture of plant-food, as well as in the destruction of decaying material. At Boise City, Idaho, some enthusiastic disciples of Izaak Walton imported and successfully reared the coveted bait for their fish-hooks in soil suited to the habitat of the Lumbricidæ. TIMOTHY E. WILCOX

Vancouver Barracks, Washington Territory,
January 30

P.S.—Are earthworms found in Arabia and Egypt?

ZOOLOGICAL RESULTS OF THE WORK OF THE UNITED STATES FISH COMMISSION IN 1883

IN the summer of 1880 the United States Fish Commission steamer *Fish-Hawk* began her first work in dredging upon the Gulf-Stream slope seventy miles south of Rhode Island, working in from 75 to 600 fathoms of water. Upon this steep submarine bank several hundred species of Invertebrates were found which proved to be new to the American coast. Many were entirely new, others had been described from the Mediterranean and the deep waters off the west coast of Europe, and some were identical with fossils from the Italian Tertiary and Quaternary deposits, this being true of the shells more particularly. These species have long since been described in American scientific publications, and two subsequent summers of work in this region have brought to light numerous new and additional species, and at the same time very nearly exhausted the region. The *Fish-Hawk*, built for the purpose of serving as a floating shad-hatching station to work in the shallow inlets of Chesapeake Bay, was, during the summer, when she could not carry on her intended work, made use of for dredging purposes, work for which she was not well suited, for her shallow draft and round bottom rendered her unsafe when far from land and liable to encounter rough weather. She could make trips only when pleasant weather was assured for at least twenty-four hours, thereby losing much valuable time which could have been saved if a perfectly seaworthy vessel had been at the command of the Commission.

Accordingly in 1882 an appropriation was obtained, and early in 1883 the *Albatross* was launched, and made her first trip shortly afterwards. So much has been written about the *Albatross* that a mere passing notice will suffice. She is a 1000-ton iron vessel, 234 feet long, and drawing 12 feet of water. On the port side, near the bows, the sounding-machine is placed. Just forward of the pilot-house is the dredging-machine, and here, in a clear space left for the purpose, the rougher work, picking out the specimens from the mud, &c., is done. Aft of the pilot-house, with a chart-room intervening, are the two laboratories and a store-room,—an upper and lower laboratory, and the store-room beneath. The finer sorting and microscopic work is done in the upper laboratory, this being lighted by a skylight and four deck-windows. The library is in this room. In the laboratory beneath are cases of bottles ready for use and for those containing specimens, and a bench is placed on two ends of the room, where rough sorting can be done. In the room below this, bottles, jars, tanks, dredges, nets, and all apparatus used in the work are contained. Alcohol is carried in a large copper tank. In the upper laboratory are two copper tanks each of 32 gallons capacity, one containing fresh water, the other 95 per cent. alcohol. By means of faucets each can be drawn from its respective tank. The rest of the ship, with the exception of a few state-rooms reserved for naturalists, is given over to machinery and quarters for officers and crew. She is manned from the navy, and is under the command of Lieut. G. L. Tanner, U.S.N. Electricity is used for lighting, Brush incandescent lights being used for ordinary purposes, while an arc lamp suspended from the rigging lights the deck so well that work can go on as well by night as by day. Engineer Baird, U.S.N., chief engineer of the vessel, has succeeded in making an incandescent light that when lowered to 100 fathoms will neither be crushed nor extinguished. Used in connection with some deep-sea trap, this will undoubtedly give good results in capturing such quick-motioned fish as would avoid the trawl but would be attracted by brilliant light. The apparatus in use is the best which the past experience of the Fish Commission, U.S. Coast Survey, and European dredging expeditions could suggest. The vessel is so constructed that she can go backward as easily as forward. When the sounding-wire is running out, she can go completely around it without causing it to depart from its perpendicular. That the *Albatross* is perfectly seaworthy and that the machinery and apparatus and the vessel itself are in the best condition has been proved by the numerous trips made during the year just passed, and by the rough weather encountered. Starting early in 1883 upon her trial trip, she went into water as deep as 1200 fathoms. Afterwards numerous trips were made in the deeper waters off the southern coast of New England, some lasting a month. The principal work was done in from 1000 to 2000 fathoms, the deepest work done on the United States coast by an American expedition. Several successful hauls were made in 2400 fathoms, and one in 2950 fathoms. This latter is the deepest successful recorded haul made with a trawl as far we can find out. Soundings were taken in 3000 fathoms. The naturalist in charge is Mr. James E. Benedict. The *Albatross* has just started on a cruise to the West Indies, where work will be done both on the shores and in the deeper outer waters.

The previous explorations of the *Challenger*, *Blake*, Norwegian, and French deep-sea dredging expeditions, investigating similar regions in the North Atlantic, have rendered the results obtained by the *Albatross* much less remarkable than they would otherwise have been. Notwithstanding this, and the fact that some worked very near the field chosen by the *Albatross*, many new species —some of them of a very remarkable character—were taken, often in great numbers. The bottom in all the hauls deeper than 1000 fathoms was of globigerina ooze, the absence of pebbles and sand being a well-marked and universal fact. Whenever mud was obtained from any locality, it was thrown into a tub of water, stirred, and allowed to settle, and by repeating this several times a perfectly pure deposit of Foraminifera was obtained. Each sounding and mud from each station was treated in a similar manner, so that samples, and often large quantities, were obtained in this manner, so that material was furnished for a complete monograph of the group. Over fifty species have been found in a partial examination of a few hauls. Every variety, both in form and in colour, is represented in these shells. Numerous new species of Gorgonians and Pennatulids were found in many localities. In these soft bottoms, where no stones are to be found, such animals or colonies of animals as must have some firm basis of attachment are almost entirely wanting. Sponges, barnacles, and hydroids are very rare, occurring at times upon the bare stalks of Lepidisis or upon some dead shell. Frequently, barnacles and Actinians are attached to these stalks, fastened in a cramped manner, the base completely surrounding the stem. The barnacles found here are very remarkable, usually being stalked, but one was taken which was sessile. A common mode of fixation among the Pennatulids is by means of a bulb-like process which projects into the mud. Acanella, Lepidisis, and their allies fix themselves by branching, root-like projections. A number of specimens of an undetermined species of Umbellifera were taken. Three new species of Epizoanthus, or, more probably, new